Two new species of Fishes from the Rolling Downs Formation (Lower Cretaceous) of Queensland are described by A. S. Woodward. They represent species of the genera Portheus and Cladocyclus, to which he gives the names *australis* and *sweetii* respectively. This discovery of these fossils is of considerable interest, since with the exception of a few Selachian teeth and vertebræ, and a fine species of Belonostomus, no cretaceous ichthyolites of importance have hitherto been described from this colony. (Ann. Mag. Nat. Hist. (6) XIV, 1894, p. 444.)

CENOZOIC.—Fossil Ants are reported from the Bembridge limestone (Eocene) of the Isle of Wight. They are referred by P. B. Brodie to the genera Formica, Myrmica and Camponotus, and some others not yet described. The first two genera have also been found in the Baltic Amber. (Nature, 1895, p. 570.)

The Champlain epoch is correlated by Prof. Hitchcock with the Mecklenburg stage of Geikie. Both have the characteristic marine mollusca fauna, the Arctic flora (*Yoldia* beds of the Baltic) and best illustrate the isobases of De Geer. (Bull. Geol. Soc. Amer., Vol. 7, 1895.)

VEGETABLE PHYSIOLOGY.[1]

Smut Fungi by Oscar Brefeld.—At last we have in two big quartos, with numerous plates, the long promised volumes on the smut fungi. The work which is here completed was begun more than 12 years ago. The earlier experiments were gathered together and published in 1883 in a volume of 220 pages with numerous plates under the title of *Die Brandpilze I*, forming Heft V of Dr. Brefeld's Untersuchungen, the most important and revolutionary portion of this volume being the demonstration that the smut fungi, a goodly number at least and presumably all of them, although previously supposed to be strictly parasitic were capable of growing saprophytically and of multiplying indefinitely in dung in the form of sprout conidia, closely resembling yeasts, if not identical with many forms previously referred to this group. Some years later in an address before the agricultural club of Berlin, Dr. Brefeld communicated the most important results of his

[1] This department is edited by Erwin F. Smith, Department of Agriculture, Washington, D. C.

magnificent infection experiments, but now for the first time we have full details of all the laboratory and field investigations. In the limits of this review it will be possible to notice only the first of these two volumes. This forms Heft XI of the Untersuchungen and is entitled *Die Brandpilze II.* It deals principally with infection experiments and gives in full the results obtained with *Ustilago Carbo* on oats, *U. cruenta* on sorghum, and *U. maydis* on maize. These experiments were carried on through a period of four years with striking results and in case of corn, with most unexpected ones. Space forbids entering into much detail. Those who wish for details will naturally consult the volume itself. Suffice to say that the infective material consisted of the yeast-like conidia propagated in nutrient solutions made from fresh horse dung.

In case of oats the best results from direct infection were 17 to 20 per cent. of smutty plants, obtained by spraying during the earliest stage of germination. Infections made when the embryo was one cm. long gave only 7 to 10 per cent of smutty plants; when it was 2 cm. long (500 plants), only 2 per cent became smutty. When the plumule had pushed through the enfolding sheath scarcely any of the plants could be infected, 200 seedlings in this stage yielding only 1 per cent of smutty plants and 200 more remaining entirely free. The infections took place through the young axis and also through the sheathing leaf so that both Wolff and Kühn were right, but a majority of the infections were through the young axis. In a second series of experiments garden earth was sprayed with the smut conidia and two days later oats were planted 1 cm. deep and subsequently transplanted to the open field: 300 of these seedlings yielded 5 per cent of smutty plants, and 300 more, 4 per cent., i. e. a much smaller per cent than was anticipated. In a third series fresh horse dung was mixed with garden earth which was then abundantly impregnated with the smut conidia. Three days later oats which had been soaked but were not yet germinated were planted in this soil at a depth of scarcely 1 cm. These seedlings were divided into two lots, 300 were kept for a time in the laboratory at a temperature of over 15°C., and 300 were placed in the cellar where the temperature did not exceed 7°C. Of the 300 kept in the laboratory 27 to 30 per cent finally became smutty; of those kept in the cellar, where germination proceeded more slowly, 40 to 46 per cent became smutty. This shows clearly that fresh horse dung greatly favors the development of smut and that weather which retards germination is also favorable. In the fourth series of experiments the infectious material was derived from conidia cultivated for a long time arti-

ficially, a few of the spores being transferred to a fresh nutrient solution every four days. The first trial (500 seedlings) was with conidia which had been cultivated in this manner for six months. These seedlings yielded from 7 to 10 per cent of smutty plants. The second trial was with conidia which had been cultivated for a year. This experiment was almost wholly negative, 300 of the seedlings yielded no smutty plants and 200 more gave only 1 per cent. The explanation was not far to seek since at the end of this period the conidia had almost wholly lost the ability to send out germtubes and along with it the power to infect the plants. Microscopic examination showed that the germtubes can penetrate into any part of the young seedling but this does not necessarily mean infection. The latter takes place only when the smut hyphæ are able to reach that part of the plant where the smut beds form. In all of these experiments the smut germs penetrated the young seedlings but the smut beds appeared only in the floral organs, some months intervening between the entrance of the fungus and the appearance of the smut in a totally different part of the plant. Those germtubes which enter the plant and fail to reach the incipient ovaries become enclosed in the mature tissues of the host plant and are incapable of further growth and this frequently occurs even in young seedlings.

The infections obtained with the big sorghum plant are even more interesting. Nearly all of the first series of infections were destroyed by a hail storm, but of the 32 plants which escaped 12 became smutty. The seedlings of the second series were infected indoor in March and set out the first of May. The plants grew luxuriantly and by the middle of August had reached a height of 5 to 7 feet. The first smutty panicle appeared August 16 and for some time thereafter it appeared as if all of the plants would be smutty, the infected panicles developing first. Finally sound ones began to appear. In the end there were 158 smutty plants out of 274. A third series of experiments was instituted to determine in what stage of germination the sorghum plant is most susceptible: 252 seedlings sprayed in the earliest stage of germination, gave 180 smutty plants. "The development of the smut in the earliest and strongest plants, which reached a height of 8 feet, was striking. The big panicles were attacked in toto and projected out of the luxuriant green foliage like black brooms." There can be no doubt that infection stimulates the growth of the plant. Older seedlings yielded less striking results: 150 which were infected when the embryo was a centimeter long, gave only 24 smutty plants; 190 infected when the embryo was 1½ cm. long gave 12 smutty panicles; 221 infec-

ted when the plumule had begun to push through the sheath gave 5 smutty plants; finally, 150 infected when the plumule had pushed through the sheath about 1 cm., remained entirely free from smut. Microscopic examinations made a few days after the conidia were sprayed on the seedlings showed that germtube penetrations were very common in that experiment which yielded over 70 per cent of smutty plants, infrequent in those which yielded only a small per cent of smutty plants, and altogether absent in the plants which remained entirely free from smut. As in oats, the smut was confined exclusively to the panicle, and the bulk of the infections took place during the earliest stage of germination, the tissues of the growing seedling very soon becoming immune.

The results with maize were very surprising since they developed three wholly unexpected facts, viz.: (1) The germtubes are capable of penetrating any young rapidly growing part of the plant; (2) The growth of the fungous hypha which has gained entrance into the plant is narrowly localized, the sporebeds developing in situ; (3) There is no period of rest, the smut beds developing immediately, i. e. within two or three weeks of the date of infection. Previous to these experiments it was supposed that corn smut entered the plant when it was a seedling and followed the same law of development as oat smut. In the first series of experiments, which proceeded upon this supposition, the smut conidia were sprayed upon 200 seedlings in the earliest stage of germination; upon 100 which were a little older; upon 100 still further advanced; and, finally, upon 100 when the plumule was pushing through the sheath. This work was done in the laboratory and after 14 days the plants were set out in the garden. Contrary to all expectation, very few penetrations could be found even by the most careful microscopic examinations, and these were confined to the root node, none being found upon the sheath,—everywhere over the surface crept the germtubes without being able to enter. These plants were under daily observation and after 10 to 14 days a few lagged behind the rest in growth, and on being pulled up smut pustules were found on the axis a little above the root node. Of the whole 500 seedlings, only a few became smutty, viz., 4 per cent in the youngest and 1 to 2 per cent in the older seedlings. In all of them the smut pustules appeared on exactly the spot where the germtubes had entered the plant and within three weeks of the date of infection. All the other plants grew to maturity and remained free from smut. Similar results were obtained from an experiment in which soaked, ungerminated kernels of corn were planted in a dunged soil which had been

abundantly infected with smut conidia. Of the 50 plants thus treated one died at the end of 4 weeks from a smut pustule on the axis, and the rest developed without any appearance of smut. Another experiment was undertaken with 150 seedlings still further advanced, the conidia being sprayed upon them, but this also gave negative results. No germtube penetrations could be found and no smut appeared upon any of the plants. These results led to a good deal of speculation and finally to the following experiments: The first of these was with plants a foot high, having a well developed cornucopia-like summit formed by the closely wrapped bases of the large outer leaves. One hundred plants were selected and into these cornucopias a nutrient solution containing smut conidia was injected. They were covered with straw matting five days to keep off rain and then freely exposed. On the tenth day, as growth continued and the infected parts were pushed up into sight, there was a changed appearance. The parts of the leaves touched by the infectious fluid were paler than the upper noninfected parts and suggested chlorosis. This appearance was visible in different degrees on all the infected plants? Already there were slight appearances of pustules and within a day or two they became very distinct, finally covering the whole infected surface with a smutty crust. Scarcely one of the male inflorescences escaped and the axis between the leaves was also smutty in so far as the infective material could reach it. Not one of the hundred plants escaped infection, the youngest suffering most. For the next experiment younger plants were selected, i. e. those about six inches inches high. In many of these the cornucopia was not well developed and allowed the infectious fluid to run out and waste and the infection miscarried. All, however, that were large enough to retain the conidia were killed outright by the development of smut pustules, the plants twisting and curving in all sorts of shapes and frequently wilting before the smut spores were mature. The third experiment was with plants 1½ feet high. Here the cornucopias were wide open and took in large quantities of the infectious fluid, which penetrated deep into the heart of the plant. After three weeks the male inflorescences appeared, but in only six plants out of 50 could any symptoms of smut be found and upon these the pustules were small and scattering. On the leaves there were wrinkled, white spots which, however, did not develop into smut pustules but subsequently became green and nearly normal in appearance. Scattered smut pustules were found on the axis at the base of the internodes in 7 cases, and the effect of the fungus was also visible on some of the upper blossoms which remained white and dried up without developing. Aside from these scattering

symptoms all of the plants remained sound, ripening normal ears. The fourth experiment, with still larger plants, gave wholly negative results. The heart of the plant proved immune, and normal ears developed. In another experiment female inflorescences were infected as soon as there was any indication of a forming ear, the Nahrlösung containing the conidia being injected into the narrow opening between the ligule and the axis. Smut pustules appeared in great numbers within 18 days but only on the parts which were actually reached by the injected fluid. Another experiment was made when the ears were in blossom. All the kernels became smutty and single ears reached the size of a child's head. In another experiment varying amounts of the lower part of the ear were protected from the fungous spray by wrapping them in blotting paper. In this case only the exposed kernels became smutty, showing again conclusively that the infection is purely local. The silk though much exposed to the conidial spray showed not the least trace of injury, having passed out of the meristematic stage. In still another experiment the kernels of the ear were sprayed with the smut conidia when they were more than ½ grown. The result was wholly negative; no smut appeared. Another experiment showed that the adventive aerial roots can also be infected if sprayed in an early stage of their growth. In short, any meristematic part of the maize plant is liable to direct infection and this is made easy by the fact, which is also Dr. Brefeld's discovery, that the corn smut fungus, unlike that of oats and sorghum, is richly provided with *aerial* conidia, which are easily carried or blown from the soil to any part of the plant. The consequent desirability of keeping the soil of corn fields free from smut spores, by removing and burning all smut pustules before they have ripened and shed, must be apparent to all. The corn smut spores seldom germinate in water, as is well known, and infection of the plant probably takes place only when the latter have an opportunity to germinate in the soil and produce the aerial conidia, this germination in the soil being greatly favored by the presence of dung. The volume contains VI, 98 pages of text and 5 lithographic plates, mostly colored.—ERWIN F. SMITH.